Environmental Health Perspectives
Vol. 9, pp. 335–338, 1974

Research Perspectives Concerning Asbestos Minerals and Their Effects on Biological Systems

by Arthur M. Langer*

The interaction of asbestos minerals with biological materials is under intensive investigation throughout the world today. Physical scientists should be responsible for the selection of fibers, and their varietal types, for biological studies; they should characterize these experimental materials physically and chemically to the level of sophistication which currently exists in their fields; they should develop definitive assay methods to monitor changes in such characteristics after biological residence; they should actively participate in the formulation of theories or mechanisms of particle interaction in biological systems.

Physical scientists should begin the characterization of minerals in the environment and the determination of ambient fiber levels in air and potable water supplies. Such characterization of the environment requires standardized instrumentation and preparation techniques. Acquisition of data in numbers large enough to achieve statistical significance requires the development of automated counting strategies. Instrumentation and software have yet to be developed. The training of physical scientists in environmental areas is lagging behind current national needs and must be accelerated.

Introduction

There is an urgent need for the physical scientist to take a leading role in the field of particle–biological systems interaction. There are many reasons for this: the physical scientist is more familiar with asbestos complexity and its behavior in a range of media; he has developed techniques for sampling and analysis of fiber at all levels of contamination; he has developed the instrumentation for fiber characterization and recognizes the statistical shortcomings in present day quantitation; he recognizes the need for precisely determining all of the chemical and physical parameters of materials used experimentally. Most important, interaction mechanisms of particles in biological systems may be clarified from the direction and perspective of the particle-end of input. Conventionally, most of the work in this field was directed toward host or tissue response rather than the nature of the materials. In accordance with the principle of biological interaction, it is imperative to have knowledge before disease stigmata appear, in addition to final response. Etiologic mechanisms may be established by prediction of response based on particle property.

What are the needs in this area that the physical scientist might fulfill?

The Need to Define Asbestos

The term "asbestos" should be explicitly defined to all experimental biologists concerned with fiber effects. The term as presently used refers to a group of flexible, silicate mineral fibers which possess, more or less, physical and chemical characteristics which render them "useful" as insulators, filtering agents, etc. Frequently, asbestos is explained as a "generic" term which includes a specific number of mineral entities. However, what is generally unknown to the biological scientist is that asbestos minerals themselves are not pure materials, but

*Mount Sinai School of Medicine of The City University of New York, New York, 10029.

occur as mixtures of varying complex crystal–chemical systems. For example, the mineral amosite is actually a member of the grunerite–cummingtonite solid solution series; crocidolite is a member of the glaucophane–riebeckite series; anthophyllite is also a member of the grunerite–cummingtonite series with additional aluminum; both tremolite and actinolite are called separate asbestos minerals, but actually they are end-members of the tremolite–actinolite solid solution series. The amphibole asbestos minerals are themselves extremely complex and never occur as chemically pure end-members. Manganese is a frequent minor element occurrence. Also, a number of other elements may be present in these minerals in substantial amounts. The asbestos minerals thus possess a range of chemical compositions which gives rise to differences in their physical properties. The chemistry of asbestos mineral fibers should be defined in mineral terms, so that similar non-economically exploited fibers will not escape notice as being potentially biologically active. The term asbestos should remain, but an awareness of its true mineral character should be created. This will be particularly important as mining and milling operations are examined in regard to their silicate minerals and their possible biological hazards. Asbestos names, and their component mineral names, should enter the biological literature. Future Lake Superiors may be avoided.

Workers in biological fields should be aware not only of the chemical nature of asbestos, but of the relationship between chemical and physical properties. That is, small changes in cation substitution, especially at specific structural sites, may greatly influence such properties as mineral cleavage or surface charge. These properties may have great biological significance in terms of mechanisms of interaction.

The Need to Determine Effects of Differing Media on Asbestos Stability

Work should begin concerning the alteration of asbestos fiber after residence in potable water. This has recently arisen after study of fibers in the sediments of Lake Superior. Fibers observed in older sediments were not identical with those in the freshly discharged ore tailings found at Silver Bay. There are indications that an ion-leaching process at the surface of the asbestos fiber removed iron from the structure, leaving an altered, highly reactive surface. If these observations are correct, then less stable asbestos mineral phases, especially chrysotile and crocidolite may alter considerably after prolonged residence in natural lake waters. The possible biological effects of such altered fibers should be investigated at this time.

The Need to Determine Biological Effects of Different Forms of the Same Fiber

There is presently being mined a new type of chrysotile deposit commonly referred to as the Coalinga-type. In this occurrence, unlike vein serpentine deposits, chrysotile occurs as mats of individual fibrils in massive lenses. From the end-products which use such material, the dusts generated are far more fine-grained than one normally encounters in those which are mined from vein deposits. The number of fine fibers and individual fibrils, smaller than 5 μm in length, are more numerous. Biological workers guided by physical scientists should be presently engaged in research defining the long-term effects incumbent upon the inhalation of such large numbers of small fibers. The effects which should be studied include both lung scarring and carcinogenic potentials.

The Need to Determine the Biological Effects of Different Fibers on the Organism–Organ-Cellular Levels

The physical scientist should work with experimental biologists in determining the effect of fiber type, chemical range, size range, surface area, surface charge, etc., on living systems. These systems should be both *in vivo* and *in vitro* models, and should include all possible interaction effects. The thrust of the work should be toward the prediction of interaction phenomena based on particle property rather than observation of results. A review of the interaction of silica and other important silicate minerals in living systems should be implemented.

The Need to Know More About Ambient Levels of Asbestos Contamination

The question arises concerning how extensive asbestos contamination in the environment really is. More information is urgently needed regarding the ambient levels of chrysotile in community air, in potable water supplies, and in human tissues. More must be learned about the sources of the asbestos fiber, including their kinds and amounts. Data are needed concerning the chemistry and physical properties of these particles and whether or not they had undergone any alteration in the environment. In an ongoing study in our laboratory, we have demonstrated the presence of chrysotile asbestos within the Greenland ice cap. Ice dated from these areas have yielded samples which go back several centuries in time. Although we know nothing of time changes as yet, we are afforded the opportunity to determine if the ambient backgrounds we now observe are the products of natural degradation of rocks or are the products of industrial usage in the twentieth century.

Concerning potable water supplies, the last major study concerning suspended mineral phases in waters was carried out in the early part of this century. This work was done by light microscopy and is at best, qualitative. Earth scientists must redo a study of this kind and on the sublight microscopic level. Ingestion of small particles, those which may easily migrate to other anatomical sites, may be of greater biological importance.

The Need to Determine Tolerable Fiber Levels in Biological Systems

Materials which are widely used in construction trades, pharmaceutical trades, etc., which might contain asbestos as a natural contaminant, should be scrutinized by both the biological and physical scientist. For example, asbestos in talc varies from major contaminant to a trace. No talc we have examined contains an absolute zero level of fiber. If a biologically acceptable level exists, it should be determined.

The Need to Standardize Instrumentation: Collection and Identification of Fiber

The instrumental techniques required for the collection and analysis of asbestos fiber in gas, liquid, or solid media need to be standardized. For example, the sampling of particulates from air should be restricted to filtration, either membrane or polycarbonate, rather than impingement or impaction devices. Analytical methods should include both light and electron microscopy and their range of instrumental techniques. More important, however, the accumulated data from all laboratories in the United States should be sent to a central governmental agency which would be responsible for the appropriate collation and evaluation of such information and its dissemination back to the various laboratories and interested governmental agencies. In order properly to evaluate such information, standard samples should be analyzed by a number of laboratories for comparison purposes. A prerequisite for such comparison is the implementation of standard sampling, preparation and analytical techniques. This is of critical importance in the areas of low-level fiber contamination.

The Need to Develop Expertise in More People

There is an urgent need for more laboratories to expand the training of technical staff for the areas of fiber analysis. The number of samples which may be processed by a single laboratory is extremely small, being limited by the requirements of time, instrumentation, and the number of individuals capable of doing the analysis. Although the instrumentation problem is readily soluble by monetary support, the qualified people required for future work should be trained immediately. These individuals are in short supply now and will be in even shorter supply as facilities develop in the future.

The Need for Automation

There is an urgent need at the present time for an automated system to be developed for the identification, characterization and enumeration of asbestos fibers in various media. This would increase the number of samples studied and yield statistically acceptable confidence levels in quantitative work. Instrumentation has now evolved to the point where automation is feasible; environmental problems have evolved to the point where quantitation is urgently needed.

All of the above research must be carried out by physical scientists working in the field of environmental medicine. There is a most urgent need for the recruitment of such individuals into this field. Most important, there exist today very few laboratories in the United States which can properly analyze materials for their asbestos fiber content. Because this field is so rapidly expanding, these laboratories, including instrumental and human resources, will quickly be overwhelmed by such work.

Acknowledgement

The author wishes to acknowledge support under a Career Scientist Award from the NIEHS, ES44812 and under a Center Grant from the NIEHS, ES00928.